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P. Stuckey McIntosh  
Chief Technology Officer

March 25, 1999

Mr. Dale Hatfield  
Chief, Office of Engineering Technology  
Federal Communications Commission  
2000 M Street, Suite 400  
Washington, D. C.

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FEDERAL COMMUNICATIONS COMMISSION  
OFFICE OF THE SECRETARY

Dear Mr. Hatfield:

This letter is in regard to the November 11, 1998 request of the Home RF Working Group (HRFWG) and its activities. HRFWG has been working to build a consortium and to develop another wireless standard for the 2.4 GHz ISM band since late summer of 1997. Home Wireless Networks (HWN) was established in 1996 and is backed by Lucent Technologies. HWN has developed a suite of products for wireless networking within the home and small office. I am HWN's chief technology officer. I have been involved in the commercial spread spectrum industry since its inception in 1985.

HWN's current products do not comply with the HRFWG spec or protocol and, at present, will not interoperate with products adhering to that spec, an early version of which was released only this month. To the best of our knowledge, there are no HRFWG-compliant products on the market. We view HRFWG's petition to the FCC as further indication that its specification is still in a state of flux.

There are a number of points which I believe the Commission should be apprised. First, the HRFWG has asked for an increased maximum channel bandwidth for frequency hopping systems. Originally, frequency hoppers were permitted 25 kHz channel bandwidth. In a 1990 proceeding, Apple Computer requested that the frequency hopping bandwidth be increased to 500 kHz. The Commission generously increased it to 1 MHz, where it stands today for 2.4 and 5.7 GHz. The rules are very clear regarding 20-dB bandwidth, and there is no room for a "favorable interpretation," as HRFWG has requested, that would permit us to say that 1 is 3, or that 1 is 5, any more than we can say that a penny is a nickel. Permitting FH channels to overlap has been strictly verboten since the advent of the spread spectrum rules – for good reason – and should remain so.

I would agree 100% with HRFWG's supposition that high-speed wireless data connectivity will stimulate the technology marketplace in particular and the national economy in general. However, I do not agree that HRFWG's proposed, slow frequency hopping will substantively contribute to this high-speed wireless connectivity, or that modifying the FH rules to accommodate the HRFWG will accomplish this. Over the 8-year course of development of the IEEE 802.11 spec, two incompatible radio standards emerged – one for

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Home Wireless Networks

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direct sequence and the other for slow FH. There is a third for baseband IR. The DS and FH standards both promised 1 and 2 megabit/second air interface rates and proportionate (70% or so) data throughput. In practice, the DS systems deliver 1.4 Mbits/sec throughput while FH systems typically eke out 300 kilobits/second.

There are a number of reasons for this. First, there is lost capacity in retuning and resynchronizing an FH system between hops. Secondly, owing to the simple but fragile and inefficient modulation/demodulation format chosen by the 802.11 FH camp (low-mod-index FSK, typically a limiter/discriminator receiver), these FH systems often lose whole hops of data to multipath distortion. Note that many of those who carried the FH banner during the 802.11 crusades have turned up in the HRFWG camp, resulting in many technical similarities. In order to meet the FCC's FH bandwidth restrictions, a 1-Mbit/sec FSK must operate with peak deviation set relatively low, resulting in a modulation index that is well below the optimum range of 0.5-0.7. The faster, 2-Mbit/sec FSK/FH, which uses a temperamental 4-level FSK waveform, requires that peak deviation be rolled back even further to remain within the FCC frequency mask. Without any multipath distortion, this 4-FSK format requires an incredible 28 dB SNR, a full 15 dB higher than an equivalent QPSK signal. Almost without exception, 2-Mbit/sec FH reverts to the more robust fallback rate of 1 Mbit/sec. Even at 1 Mbit/sec, multipath will often obliterate fully one-third of all hops. That leaves about 300 kilobits/second once packet addressing and other air-interface overhead is accounted for. A little popcorn in the microwave will further erode this somewhat lackluster performance.

In its proposal to have FH bandwidth increased to 3 or 5 MHz, HRFWG disregards the medium through which its signals must propagate: air. At these higher bit rates, it will find its multipath problems are exaggerated. With a symbol time of 200 ns and promised bit rates of 5 or 10 Mbits/sec, typical, in-building multipath delay spreads will chew up an even greater percentage of HRFWG packets, necessitating retransmission and, in all likelihood, falling back to the old 1-Mbit/sec air-interface rate. This is a nominal 10 Mbit/sec LAN.

We disagree strongly with HRFWG's supposition that the proposed changes "would not cause harmful interference to other users of the band."<sup>1</sup> Spread spectrum radio is afforded no statutory protection from interference. MIPS of signal processing horsepower, frequency agility, and regulatory stability are three of the things that sustain us. The ISM bands are a free-or-all. We all knew this when we got into it, and we're not complaining. Every one of us is trying to pack as much anti-jamming capability into our products as we can. The military ECM (electronic counter measures) process of detect, identify, classify, and deny are fast becoming the mantra of spread spectrum radio designers as the bands become more fully occupied. At HWN, we attain a substantial measure of interference rejection via fast DSP algorithms implemented in hardware ASICs. ASICs are expensive to redesign and retool. The algorithms are tailored to known and permitted sources of interference – from narrowband, analog-FM to the widest and fastest hoppers. Opening up FCC Part 15.247 for substantive changes regarding permitted FH bandwidth could disrupt 10 years of progress and impact hundreds of millions of dollars of invested capital. We urge the Commission to reject HRFWG's request in its entirety.

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<sup>1</sup> HRFWG petition letter page 4/9

HRFWG's supposition that "Allowing a similar degree of flexibility for frequency hopping systems as recently allowed direct sequence systems will foster competition..."<sup>2</sup> is inaccurate and uninformed. There were no recent changes to the rules regarding direct sequence spread spectrum systems nor is the flexibility to which HRFWG refers recently allowed. HRFWG's clamoring is, no doubt, a reference to the recent certifications granted to 11 Mbit/second DS systems. The rules are clear and unambiguous. They state that DS bandwidth must be *greater than* a mandated minimum (500 kHz) and that FH bandwidth must be *less than* a mandated maximum (1 MHz in the 2.4-GHz band). If one were seeking to transmit high-speed data, DS mode seems the natural place to look – it's where the bandwidth is.

HRFWG's letter petition suggests that multiple-bit-per-symbol DS is something new. In fact, manufacturers of 2.4-GHz, point-to-point microwave links first availed themselves of this facet of the DS provision as early as 1992<sup>3</sup>. Others followed suit, and it is now standard practice among all manufacturers of these products. HRFWG may not be aware of this long history and firm precedent.

The HRFWG adopted an FH approach of its own volition, but it's not too late for it to change. Should HRFWG elect to stick with an FH approach, there are any number of higher-performance solutions such as 16-QAM/FHSS with adaptive equalization. Products using these same techniques have been on the market for some time and are being sold by HRFWG's competitors.<sup>4</sup>

HRFWG's request that its petition be allowed because it will agree to an attendant reduction in RF transmit power is a throwaway, a red herring. It is difficult and expensive to obtain RF-transmit power exceeding 100 mW in any battery-operated, portable device. Go for higher transmit power, and a handheld device will heat up, battery life will plummet, and range will improve only nominally. At only 200 mW, testing to SAR limits<sup>5</sup> is required and may dictate that a manufacturer place a health warning label near the transmit antenna. A transmitter of greater than 200-mW strength in an HRFWG application is unlikely. Were the HRFWG willing to roll its transmit power back to 1 mW, it could qualify under 15.249 and use any hopping bandwidth.

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<sup>2</sup> HRFWG petition letter page 6/9

<sup>3</sup> Western Multiplex Corporation (now a part of Glenayre Technologies), Lynx, 2.4-GHz, direct sequence spread spectrum point-to-point microwave link, FCC ID HZB-LYNX12, granted June 8, 1992

<sup>4</sup> WaveAccess (now a part of Lucent Technologies) 3.2 Mbit/sec, 2.4-GHz, Jaguar wireless PCMCIA card, Model PC132, FCC ID NCAPC132V100JGUS, granted August 18, 1997

<sup>5</sup> SAR – Specific Absorption Rate limits pertaining to RF heating of human tissue, ANSI/IEEE C95.1-1992



HRFWG's current difficulties - a lack of throughput - are of its own design. HRFWG's problems are technical in origin, not regulatory. We urge that the HRFWG's petition be denied in its entirety.

Sincerely,

A handwritten signature in black ink, appearing to read 'P. Stuckey McIntosh', is written over the word 'Sincerely,'.

P. Stuckey McIntosh  
Chief Technology Officer  
Home Wireless Networks

cc: Julius Knapp  
Karen Rackley  
John Reed  
Neil McNeil